One-dimensional Advection/Diffusion Passive Scalar

1 Introduction

This case provides a description for one-dimensional time advancement of a passive scalar, i.e., constant velocity, whose partial differential equation (PDE) includes the effects of advection and diffusion.

2 Domain

The simple two-dimensional geometry for this tutorial is captured in Figure 1 where the key length of the domain is unity.

The left and right surfaces are periodic while all other surfaces are zero flux. A constant velocity of $u_x = 1$ is applied to the scalar transport equation. A viscosity, ν, is specified to be 0.01, resulting in a Peclet number of 100 based on the domain length and unity based on the local mesh spacing ($Pe = UL/\nu$). The initial condition is simply a Gaussian distribution, see /src/user_functions/ScalarGaussianAuxFunction.C.

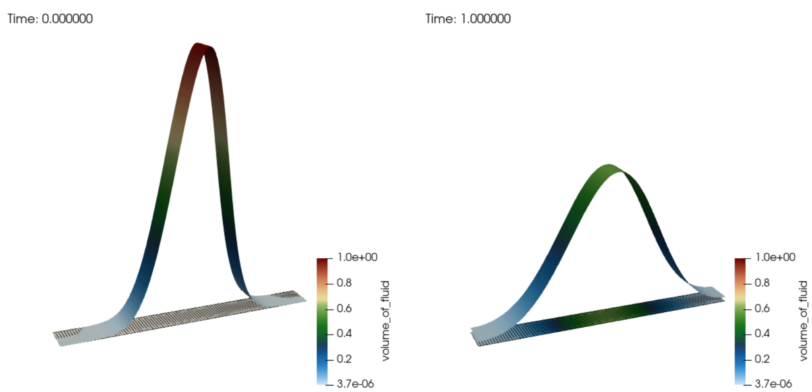

Figure 1: Two-dimensional domain capturing a one-dimensional evolution of a passive scalar at the time of 0 and 1.

3 Theory

The time varying transport of scalar ϕ is given by,

$$\frac{\partial \phi}{\partial t} + u_j \frac{\partial \phi}{\partial x_j} + \frac{\partial q_j}{\partial x_j} = 0, \tag{1}$$

where q_j is the diffusive flux given by,

$$q_j = -\nu \frac{\partial \phi}{\partial x_j}. \tag{2}$$

3.1 Simulation Specification and Results

The mesh exercised activates a Hex8 topology, thereby exercising a linear basis that yields a nominal second-order spatial accurate simulation. A BDF2 three state scheme is applied for a fully implicit evolution. The simulation can be extended in time. The periodic domain mimics and infinately long domain.

4 Discussion Points

There are several interesting activities associated with this sample case including the following:

- Explore the mesh and input file specifications associated with this case.
- Explore the specification of viscosity: increasing and decreasing the nominal value by 10x. What do you see?
- The current advection operator is specified as "scs_upw_advection_np". What happens if you activate "scs_advection_np", again in the context of modification of the viscosity by 10x?
- What happens when viscosity is set to zero?
- Based on what you have learned in class, what is the controlling numerical principle?